of the mouth. The second kind is homologous with the prehensile organs of the Diphydæ and Physophoridæ, and with the peculiar clavate processes of *Plumularia*. All these organs commence their development as bud-like processes of the two joining membranes. The peculiar clavate organs of *Plumularia* are developed from the common tube independently of the stomach. They have not been hitherto described, and were observed by the author in two species of *Plumularia* dredged at Port Curtis. They were of two kinds, the one attached to the cell of the polype, the other to the pedicle of the ovary. To each species there were three processes of the former kind, two above proceeding from near that edge of the aperture which is towards the stem, the other below from the front part of the base of the cell. They were conical in one species, club-shaped and articulated in the other, and consisted of an external horny membrane open at the apex, and an internal delicate membrane inclosing a cavity, all these being continuous with the corresponding parts of the stem. At the apex of each, and capable of being pressed through the aperture, lay a number of thread-cells. The second kind of organ was present in the species with conical processes. It consisted of a stem proceeding from the pedicle of the ovary, bearing a series of conical bodies, having the same constitution as those just described; the whole bearing a close resemblance to the prehensile organs of the Diphydæ.

The following table exhibits the homologies of the several families, which must be regarded as by no means so distinct as hitherto supposed, but rather as members of one great group, organized upon one simple and uniform plan, and even in their most complex and aberrant forms reducible to the same type.

Stomachs identical in Structure throughout.

Medusæ.	*Physophoridæ.*	*Diphydæ.*	*Sertularidæ.*	*Hydræ.*
Disc	Natatorial organ	Natatorial organ.		
Canals	Canals of natatorial organ	Canals of natatorial organ.		
Common cavity Canals of branches (*Rhiz.*)	Common tube	Sacculus and common tube	Cavity of stem.	
	Bract.		Polype-cell.	
Tentacles, 1.	Thickened edge of stomach		Oval tentacles.	
2.	Prehensile organs.		Clavate organs	Tentacles (?).
Generative organs	Generative sac		Generative organ.	Generative organ.
	Natatorial organ of generative sac			Natatorial organs (Coryne).
Marginal vesicle	?		?	?

2. "Memoir to accompany a Map of the Magnetic Variation for 1840 in the Atlantic Ocean between the parallels of 60° N. and 60° S. latitude, being Contributions to Terrestrial Magnetism, No. 9." By Lieut.-Colonel Edward Sabine, R.A., For. Sec.R.S., and printed in the Philosophical Transactions.

In this Number of the Magnetic Contributions the author gives maps of the Magnetic Declination in the Atlantic in January 1840, between the parallels of 60° N. and 60° S. lat., founded on 1480 de-

terminations, by observers of different nations, all comprised between the years 1828 and 1848 ; each determination being in the majority of cases a mean of several distinct and independent observations, and all reduced to the epoch of 1840, by the rates of secular change derived from a comparison of Hansteen's map of 1787 with the present state of the phenomena.

A considerable portion of the determinations thus co-ordinated having been obtained on board ships in which measures were taken to supply the means of correcting the errors occasioned by the influence of the iron which the ships contained, the author in an accompanying memoir has discussed at some length the *variable* part of the corrections required for that purpose, being that portion of the correction which varies as a ship changes her geographical position. He infers from the observations generally, and especially from those of H.M.S. Erebus during the Antarctic Expedition in 1839–1843, that the disturbance occasioned by the iron is chiefly, if not entirely, due in wooden ships to the induced magnetism of the iron ; but that its changes are not so rapid as those of the terrestrial magnetic Inclination and Force during changes of geographical position, and that the magnetism of the ship is consequently at such times liable to become more or less *in arrear*, if the expression may be permitted, of the change which the magnetic inclination and force have undergone; that in fact there are considerable portions of a ship's iron which are not permanently magnetic on the one hand, nor perfectly soft so as to undergo instantaneous change with changes of inclination and force on the other hand; and which derive magnetism by induction from the earth, but conform *gradually* rather than *instantaneously* to the changes of terrestrial magnetism corresponding to changes in the ship's place.

The bearing which this new view of a ship's magnetism would have on the endeavour to counteract the disturbance occasioned by the iron, either by permanent magnets or by soft iron, is noticed, and the conclusion is arrived at, that in order to correct magnetic observations made on board ship, it is desirable to determine experimentally the variable term in the correction formulæ, at intervals of not many days apart when a ship is changing her geographical position. An apparatus and method of observation to accomplish this purpose are described, which are stated to be extremely simple, to require no unusual circumstances of weather and no reference to celestial objects, and to occupy but a very few minutes.

In conclusion, a comparison is instituted between the declinations computed by M. Gauss's general theory and those now derived from observation over a field of considerable extent; and on this comparison the author founds the following remark, "that the general theory will require to have its numerical coefficients reconstructed before it can become available for practical purposes ; and that those who desire to take a correct view of the magnetic phenomena, must for the present at least, have recourse to the maps constructed directly from the observations themselves."

3. "On the Microscopic Structure of the Scales and Dermal Teeth of some Ganoid and Placoid Fish." By W. C. Williamson, Esq. Communicated by Edwin Lankester, M.D., F.R.S.

The author commences his paper by stating that the structure and modes of growth of fish-scales have been studied by many observers, especially by Leeuwenhoek, Agassiz, Mandl and Owen. The first of these considered each scale to consist of numerous superimposed laminæ added successively to the inferior surface. This view has been revived, with some important modifications, by M. Agassiz, and especially applied to the scales of ganoid fish; which he showed to consist of laminæ of true bone, usually covered with enamel (*émail*), the latter often resembling the dentine of fishes' teeth. M. Mandl denied that ganoid scales had been formed by such successive additions of laminæ; and Professor Owen also opposed the idea, that they had merely been the result of successively excreted deposition. The author then proceeds to the examination of the scales of the following genera and species:—*Lepidosteus osseus*, *Lepidotus semiserratus*, *L. Mantelli*, and *L. fimbriatus*, *Seminotus rhombifer*, *Pholidotus Leachii*, *Ptycholepis Bollensis*, *Beryx*, *Dapidius orbis*, and *D. granulosus*; all of which appear to be constructed according to a common type—one singular modification of which is seen in *Palæoniscus comptus* and *P. Beaumonti*, and another in *Gyrodus* and *Aspidorhynchus acutirostris*. Still more elaborate complications occur in the scales of the Sturgeon and of *Platysomus parvulus*, the minute structure of which is described. Then follow detailed accounts of another interesting group of structures found in the genera *Megalichthys*, *Holoptychius* and *Diplopterus*, in which the osseous tissues and their superficial coverings are exceedingly beautiful and complicated. The next fish examined is *Macropoma Mantelli* from the chalk. In this the true bony operculum is studded over with dermal teeth, as is also the posterior part of each scale; the portion of the latter, however, which is subjacent to these dermal teeth, is not osseous, but consists of thin laminæ, which do not contain lacunæ. The hollow viscus found in the interior of the *Macropoma*, is shown to be a cylinder of true osseous tissue, of a singular laminated structure full of lacunæ. The author rejects the idea of its having been a stomach, but thinks that it may have served the purpose of an air-bladder.

The structure and arrangement of the dermal teeth from the skin of the Dog-fish are then investigated, and appear to resemble those on the opercular bones and scales of *Macropoma*. Similar teeth are described in the fossil skin of *Hybodus reticulatus*, from the lias of Lyme Regis. In the latter, numerous small granules of calcareous matter, having a concentric laminated structure, have been imbedded in the substance of the soft cutis, under the dermal teeth. The corresponding dermal teeth from the *Raia clavata* are described, and also those covering the snout of the common Saw-fish; as well as the very singular premaxillary bones of the *Cœlorhynchus*.

From an examination of the dermal appendages of the fishes thus cursorily enumerated, the author concludes—

That what has hitherto been termed enamel, is in fishes a compound structure, separable into ganoin and kosmine (κόσμειν, *to adorn*); the former being transparent and laminated, but otherwise structureless, whilst the latter consists of minute branching tubes resembling the dentine of true teeth.

That the kosmine covering the osseous scales of so many ganoid fish, as in *Lepidotus semiserratus*, *Megalichthys Hibberti*, &c., is homologous and identical with the substance composing the dermal teeth of the true placoids, such as the Dog-fish, Thornback, &c., only that, whilst in the former the areolæ of kosmine are aggregated upon bony scales, in the latter they are implanted in the soft integument, without the intervention of any bony matter. It follows from this, that the distinction of "ganoid" and "placoid" is scarcely a physiological one, inasmuch as the scales of many so-called ganoid fish, such as *Dapidius orbis*, *Acipenser*, &c., exhibit little or no trace of either ganoin or kosmine; that in many of the Placoids these substances are very largely developed; and that a series of well-defined links exist, passing through the common Thornback, the common Spotted Dog-fish, *Hybodus reticulatus*, *Macropoma Mantelli*, *Dapidius granulosus*, *Holoptychius*, *Diplopterus* and *Megalichthys*, by which the ganoid and placoid forms merge in one another.

That ganoid scales consist of variously modified osseous lamellæ, the result of successive additions made chiefly to the lower surface of each; but also, under particular circumstances, either to a part, or to the whole of the upper surface.

That these lamellæ have not been the result of any process of excretion, or depositions from a secreting surface, as supposed by M. Agassiz, but that they have been formed by the calcification of the lower laminæ of an investing vascular periosteum; and that consequently the phænomena attending the structure and growth of these ganoid scales contribute in a material degree to establish the correctness of the views recently promulgated by Professor Sharpey respecting the growth and development of human bone; the gradual formation of Haversian canals being traced with great ease from the simple laminæ seen in the scales of *Lepidosteus*, *Lepidotus*, &c., through *Aspidorhynchus*, *Acipenser*, *Holoptychius*, &c. to their high degree of development in *Megalichthys*.

That the study of the microscopic structure of the dermal appendages of fish may, when carried on with due caution, be made a valuable auxiliary, both in distinguishing between allied species, and in establishing the existence of important affinities, even when applied to otherwise insignificant fragments; but that it is capable of being overstrained, and of leading to erroneous conclusions, if any classifications are founded upon it irrespective of the other portions of the fish to which the scales belong, because of the unequal ratio in which the various parts of an organism may have been developed. Thus, whilst *Lepidosteus osseus* presents one of the simplest forms of ganoid scales, it has the concavo-convex vertebral articulations of the Ophidians; on the other hand, in many species, as in *Megalichthys* and *Holoptychius*, whilst the structure of each part of the exo-

skeleton is highly developed, the vertebræ appear to have the double concave articulation common amongst fish and enaliosaurs.

The author, in conclusion, acknowledges his obligations to Sir Philip M. de Grey Egerton, M.P., Dr. Mantell, Mr. Binney, Mr. J. E. Gray and Mr. Searles Wood, for their valuable co-operation in supplying many important specimens for examination.

4. "On the Mechanical Equivalent of Heat." By J. P. Joule, Cor. Associate R. Acad. Sciences, Turin, &c. Communicated by M. Faraday, D.C.L., F.R.S., Foreign Memb. Acad. of Sciences, Paris, &c.

After passing in review the experimental researches of Rumford, Davy, Dulong, Faraday, and others who have successively discovered facts tending to prove that heat is not a substance, but a mode of force, the author mentions the papers he has already communicated to the Royal Society, and published in the Philosophical Magazine, in which he has endeavoured to show that in the production of *heat* by the expenditure of *force*, and *vice versâ*, in the production of *force* by the expenditure of *heat*, a constant relation always subsists between the two. This relation he denominates the "Mechanical Equivalent of Heat," and the object of the present paper is to advance fresh proofs of its existence, and to give to it the numerical accuracy requisite to fit it as a starting-point for further inquiries.

In carrying out the above design, the author has determined the relation of *work done* to *heat produced* in the cases of the friction,—1st, of water; 2nd, of mercury; and 3rd, of cast iron.

In the experiments on the friction of the fluids, the liquid was contained in a covered cylindrical vessel of copper or iron, and the agitation was effected by vanes of brass or iron, fixed to a vertical axis revolving in the centre of the vessel, whilst fixed vanes prevented the liquid being whirled in the direction of rotation. In the experiments on the friction of solids, a disc of cast iron was rotated against another disc of cast iron pressed against it; the whole being immersed in a cast-iron vessel filled with mercury.

The *force expended* was measured by the descent of the weights employed in rotating the apparatus; and great care was taken to correct it for the friction of the axes of the pullies employed, &c.

The *heat evolved* by the friction was measured by exact thermometers, and very laborious precautions were taken in order to eliminate the effects of radiation or conduction of heat to and from the surrounding atmosphere. The corrected thermometric effect was then reduced to a known capacity for heat, by means of extensive series of experiments made in order to ascertain the specific heat of the materials in which the thermometric effect was observed.

In this way the number of units of work, estimated in pounds one foot high, required to be done in order to develope one degree Fahr. in one pound of water taken at about 50°, was found to be as follows:—

772·692 from friction of water, a mean of 40 experiments.
774·083 from friction of mercury, a mean of 50 experiments.
774·987 from friction of cast iron, a mean of 20 experiments.